Ethanol Explosion

Energy in Combustion Reactions

Introduction

There is any number of reasons for doing this reaction. It fits in nicely with any of the following topics: exothermic reactions, activation energy, combustion, alternative fuels, and oxidation reduction to name a few.

Concepts

- Activation energy
- Combustion
- Exothermic reactions

Materials

Ethyl alcohol, 95%, 1 mL
Bottle, narrow mouth, polypropylene, with cap, 30-mL
Bottle, narrow mouth, polypropylene, with cap, 125-mL
Cork, size 3
Cork, size 5
Hot glue gun
Metal screws, 4
Pompons or Styrofoam® balls, 2
Safety shield (highly recommended)
Tesla coil

Safety Precautions

Please read all safety precautions before proceeding with this demonstration.

- Ethyl alcohol is a flammable liquid and a fire hazard. Due to the denaturant it is toxic by ingestion. Use in a well ventilated room.
- *Always* recap the ethyl alcohol bottle and move it far from the demonstration area. Never leave an open bottle of alcohol in the vicinity of the demonstration.
- A safety shield is highly recommended for explosions. Even the mildest explosion creates some chance of shattering and flying objects. Protective eyewear must be worn by the demonstrator as well as by anyone viewing the demo.
- *Never* perform alcohol explosions in glass bottles. The large quantities of gases (H_2O and CO_2) produced during the rapid combustion will easily shatter a glass container. Serious accidents have occurred performing this demonstration in a glass container—do not use glass. Use a narrow mouth bottle made from plastic such as polypropylene.
- Always pour out excess (non-volatilized) liquid ethyl alcohol from the plastic bottle before igniting. If any liquid alcohol is left, it will increase the amount of gaseous afterburning. The liquid could also ignite, which may cause the plastic bottle to melt. Always keep a lid or some sort of cover handy, which can be placed over the mouth of the bottle to extinguish the flame if it continues so long as to begin melting the plastic. Excess alcohol on the outside of the bottle should be wiped off in order to avoid its igniting and softening the plastic bottle.
- *Never*, ever use a pure oxygen environment as the potential for an extremely violent and deadly explosion is possible.
- Never use methyl alcohol for this demonstration. The high volatility of methyl alcohol means that it has the potential for the most violent combustion of any alcohol.
- Replace the plastic bottle when it shows grazing, frosting, cracking, or any small flaws. Routinely replace the bottle after approximately 20 uses or so.
- Do not perform this demonstration directly underneath smoke/heat detectors or sprinkler systems.
- Make sure the ceiling is at least 4 feet above the bottle to prevent possible scorching and fire.
- *Always* wear protective eyewear when performing this demonstration. Please consult current Material Safety Data Sheets for additional safety information on ethyl alcohol.

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Preparation

1. Using two of the screws, fasten the screws into opposite sides of the 30-mL polypropylene bottle. Inside the bottle the two screws should be no more than 0.5 cm apart.
2. Use the hot glue gun to glue around the screws where they join the outside of the bottle.
3. Use the hot glue gun to attach a pompon to the top of the cork.
4. Repeat the Preparation procedure with the 125-mL polypropylene bottle.

Procedure

1. Add about 1 mL of ethyl alcohol to the 30-mL plastic bottle. Recap the bottle of ethyl alcohol tightly and move it far from the demonstration area.
2. Lay the bottle sideways on a flat surface allowing the alcohol to flow from base to mouth. Slowly swirl the bottle for about 30 seconds, trying to spread alcohol liquid completely over the entire interior surface. This allows the liquid alcohol to volatilize and makes the vapor concentration uniform throughout the bottle.
3. Pour out any excess liquid alcohol into a waste container and shake out the bottle. Move the waste container far from the demonstration area.
4. Lightly place the cap on the bottle and ensure the bottle is behind a safety shield.
5. Dim the lights in the room.
6. Turn on the Tesla coil and with the Tesla coil at arm's length; bring the end of the Tesla coil close to one of the screws. *Note:* Be sure you are on the safe side of the safety shield as well.
7. Observe the explosion that results.
8. After the reaction has subsided and all the flames are out, wait for a moment or two until the bottle has cooled slightly before touching the bottle.
9. Try to repeat the explosion in the 30-mL bottle immediately. Of course, no explosion will occur due to the lack of oxygen inside the bottle.
10. Repeat steps 1–8 with the 125-mL polypropylene bottle.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Excess alcohol may be disposed of by allowing it to evaporate in a fume hood according to Flinn Suggested Disposal Method #18a. Before storing the bottle, allow it to remain open to the air to allow any remaining vapors to be released.

Tips

- The demonstration works best if the alcohol vapor is prepared immediately before the demonstration. If the bottle with the vapor sits for a while, the vapor tends to settle and is harder to light.
- Propyl alcohol burns slower producing more heat, which may damage the bottle. *Do not try this demonstration with methyl alcohol.* The high volatility of methyl alcohol means that one must be particularly cautious when using methyl alcohol as it has the potential for the most violent combustion and possible rupture of the bottle.
- The demonstration cannot be repeated immediately. The demonstration will not work due to the buildup of CO_2 in the bottle. There is not enough oxygen in the bottle to allow combustion to occur.

Discussion

Ethyl alcohol evaporates, forming an explosive mixture with the air in the bottle. When the Tesla coil is touched to one of the screws, a spark jumps across the gap from one screw to the other. This spark provides the activation energy needed for the combustion of the ethyl alcohol-air mixture. Since the burning is rapid and occurs in a confined space, an explosion occurs. The equation for the reaction is:

$$2CH_3CH_2OH(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g) \qquad \textit{Equation 1}$$

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation

Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter, transfer of energy

Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, chemical reactions, interactions of energy and matter

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Ethanol Explosion* activity, presented by Penney Sconzo, is available in *Energy in Combustion Reactions* and *Stoichiometry in Combustion Reactions*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Ethanol Explosion* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP5443	Tesla Coil
AP8303	Cork, Size 3, Pkg. of 100
AP8305	Cork, Size 5, Pkg. of 100
AP8431	Bottle, Narrow Mouth, Polypropylene, with Cap, 30 mL
AP8433	Bottle, Narrow Mouth, Polypropylene, with Cap, 125 mL
E0009	Ethyl alcohol, 500 mL
SE261	Safety Shield

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.